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The self-organization of financial markets

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Abstract
Financial markets can be modeled as self-organizing systems. Key internal processes include the coordination of expectations and the evolution of strategies. Information in this context is generated internally by the system itself. One implication is that reasonable investors can have heterogeneous views. This model helps explain empirical facts including uncertainty, diversity of opinions, and communication, which combine to produce inefficiencies like momentum, value, trends and reversals. The general model can be used to develop more specific analytical frameworks, e.g. a model that helps navigate through the cycle of expectation coordination.

Key words
Self-organization
Diversity of opinions
Market cycles
Capital markets theory

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Introduction

Market developments over recent years have yet again shown how detached the still-ruling paradigm of efficient markets is from reality. This paper aims to take a deeper look into this reality. In terms of paradigmatic reference, the presented model is rooted in systems theory, as propagated by Humberto Maturana, Heinz von Foerster, and many others.
Other influences include Hayek's theory of complex phenomena [Hayek 1967] and Keynes' famous chapter 12 of his General Theory [Keynes 1936]. The main "non-academic" influences are George Soros' theory of reflexivity [Soros 2003] and Alfons Cortés' work on trends[1].

Empirical phenomena – key market facts

Among many interesting market phenomena, there are a few facts that strike me as being of particular relevance. I call them the key market facts.

- Investors are bad at forecasting (uncertainty).
- Investors have differing views (heterogeneity of expectations).
- Investors communicate.
- Markets tend to move in trends.
- Trends tend to revert, creating "cycles".

I would like to ask readers to judge the quality of the following theoretical considerations on whether they contribute to our understanding of these phenomena or not.

Why systems theory?

Systems theory is about "circular" causality, i.e. self-referential feedback loops. If there is reason to assume that such feedback plays an important role in financial markets, then it might be worthwhile to look at systems theory for an explanation.

A key property of self-organizing systems is the fact that inputs do not directly cause system behavior. Rather, they are a stimulus that is processed according to a system's internal structure. In turn, the system operations feed back on the internal structure, which is what makes such systems adaptive.

In the financial markets, a piece of fundamental news never causes a certain market reaction. As an example, let us say that company X announces an earnings increase by 50%. Good news? Will the share price rise? Obviously, this cannot be answered without taking into account the market's expectations. If investors had expected a doubling of profits and hence expectations need to be adjusted downwards after the announcement, the share price will most likely fall. This illustrates that fundamental inputs do not cause market behavior, but that price reaction depends on the market's internal structure, mainly the state of expectations.

The nontrivial machine

A more formalistic representation of circular causality is provided by the cybernetic concept of the nontrivial machine. A trivial machine simply relates an input "i" to its output "o" via some transformation function "f".
$o=f(i)$
This is the standard deterministic model. The nontrivial machine combines at least two trivial machines, with one machine constituting a feedback loop involving the internal state "z", determined via the state function "G", the iteration of which provides "z'".
$o=F(i,z);$
$z'=G(i,z)$

Self-observation

In order for a self-referential loop to exist, a system needs to "observe" itself. In the markets, self-observation is a familiar occurrence. Investors observe the market all the time, looking for example at price trends, sentiment indicators, valuations, capital flows and investor positioning, etc.
To illustrate what this means, assume that someone has found a winning strategy (e.g. a quant model). This will attract money. Hypothetically, assume that all money in the market ends up being managed according to this strategy. Obviously, the strategy will fail, as it is impossible by definition for all investors to beat the market. So, the growth of the strategy changes market behavior. This

type of feedback is what defines a nontrivial machine.

Why we can disagree and both be right

We have all learned that an efficient market is a market where rational investors evaluate all available information correctly. Some of us have been questioning whether real-world people can meet this ideal. Behavioral Finance has become popular showing that investors are only human, with all their biases, emotions, and cognitive limitations.
However, we have been so deeply imbued with the traditional notion of rationality that only few of us question the underlying concept of information. The key point to understand here is that the idea that information is objectively available, and can – at least in principle - be evaluated in a binary right/wrong way, is far from undisputed.

A difference that makes a difference

Firstly, in systems theory information is defined as an event that can change system structures, or, in Bateson's famous words, as "a difference that makes a difference" [Bateson 1972]. In systems theory, information is not objectively given, but depends on the observer. More radically: Information is created by the distinctions that a system uses in making observations. The same event may have different meanings to different observers.
This is relevant to the investment world. As an example, take an earnings announcement. What is its meaning? If you are a long-term value investors, you will hardly be interested in the headline. You will dig into the details of the report, discuss critical points with the company's management and finally arrive at a judgment of whether or not long-term prospects and the company's value have changed. Now imagine you are running a news-trading algorithm. The computer will not be interested at all in long-term value considerations. It will look at semantic relations in the news announcement and make a split-second decision. What if you are a more traditional "quant"? Your model will ask whether the announcement changes the stock's earnings momentum and earnings revision factors. And if you are a technical analyst, you will not be interested in the announcement at all, but only look at the stock price reaction.
So, does the earnings announcement have an objective meaning? Is it possible to say that information is "available", i.e. is provided to the market from the outside? I guess not. Rather, the market generates its own information, based on the mix of diverse distinctions that investors apply.

Complexity and the surplus of possible explanations

Secondly, most will probably agree that the economy is a complex system. In systems theory, complexity implies that system operations are "contingent" (a technical term), i.e. there are different choices for the selection of an operation. This means that there is not only one possible path of development, but multiple future paths are possible *ex ante*. For example, some investors may think the US economy is facing deflationary risks, while others are worried about a strong increase in inflation. Who is right? Obviously, both outcomes are possible (and many others in between), depending on a complex network of future actions which, as of today, are unknown.
So how do we decide which future path we consider most probable? Clearly, most analysts, economists and informed investors apply some kind of model, ideally based on theoretical considerations and historical precedence. Do all observers use the same models? Obviously not. With the economy being more complex than any description an observer might make, it follows that there is a surplus of possible descriptions, requiring selection. Selectivity of knowledge was important to Hayek, who concluded that it is not possible to make forecasts of specific outcomes when complex systems are concerned, but only to make what he called "pattern predictions" [Hayek 1967].

We may disagree, yet we are both right

So, the most basic market facts are uncertainty and the resulting heterogeneity of expectations. We do not know what the future will look like, and we have more than one possible way of looking at the economy. Combining uncertainty and a surplus of possible interpretations, it is clear that investors can and do have differing opinions about the future.
The key point is that if the above is true, different opinions may be equally rational. So we can disagree, and we can both be right (*ex ante*).

Market communication and investment propositions

What do we do if we know that our individual knowledge is limited? We communicate. Given the pervasiveness of communication in the market, it is amazing that the literature on this phenomenon appears to be extremely limited. Please note that communication comprises both traditional verbal and written debate (research by analysts, economists and academics, public statements by investors, financial topics in the mass media, etc.) and signals provided by the market itself (price levels and changes, the related volatilities and correlations, trading volumes, valuation signals).
Communication has a few interesting properties. First of all, it generates and is based on themes. A market theme is a hypothesis offering an explanation of what is going on. Famous themes include the "New Normal", the "New Economy", "Great Moderation", "BRIC", and so on. The list is endless. Every economic process that creates uncertainty can trigger debate and hence be subject of a market theme, from the big macro issues down to micro themes that impact only individual companies.

Themes create investment propositions

Themes as explanatory constructs are necessarily simplifications, reductions of complexity. This is nothing bad, but essential for us to be able to make decisions as investors. We are lost in complexity if we do not simplify and rationalize. A theme thus makes a complex situation decidable.

In other words, a theme creates an investment proposition. As investors, we are now presented with a choice: We can either reject or endorse the theme. For example, we can now say the "New Normal" makes a lot of sense to us and value assets on the basis of low growth expectations. Or alternatively, we can bet against this.

Importantly, as investors we take part in the debate even if we isolate ourselves from all channels of traditional communication. We still see market prices and are forced to make sense of them in order to make a decision. For example, we may do our valuation homework and conclude that market expectations are too negative, so we buy. As soon as we make this purchase, we take a position in the market debate and contribute to its further evolution.

As pointed out above, there is uncertainty with regard to a theme. Importantly, complexity implies that it is not possible for single data points to validate or invalidate a theme. How do you invalidate the "New Normal", for example? As a consequence, it takes repeated confirmation or contradiction by the news flow to shift the pendulum of evidence, introducing time into the market's evaluation of fundamental data.

It is helpful to categorize themes along two key dimensions of uncertainty: perceived complexity and contingency. The latter term denotes the degree of indeterminacy of outcomes, and clearly, only high contingency situations are of interest. The former, complexity, is proportional to the number of variables and relations that determine an economic process and the size of the potential outcome space. The most relevant themes are high complexity/high contingency constellations. These are the big picture macro themes. Going down the complexity scale, we come to industry and company themes. The lower the complexity, the more data-dependent (i.e. less structured by communication) a situation becomes. Themes whose complexity is so low that they can be either validated or rebuffed with a few pieces of news generally will not serve as a driver of perception-transforming propositions.

The structure of expectations and market inefficiencies

Communication coordinates expectations and thus leads to the formation of market-internal expectation structures. It focuses investors' perceptions on the market's themes and polarizes views along the poles of acceptance or rejection. In traditional finance, this is not supposed to happen. The idea of efficient markets either requires all investors to share the same view of the future or – if allowing for diverse opinions – requires that investors reach their views independently of each other. Obviously, communication violates this assumption. Communication means we are all connected.

Logically, the structure of investors' expectations in relation to a theme can take two general forms:

- Polarization: Investors disagree on a theme. There are pronounced differences in views.
- Synchronization: A consensus exists with regard to a theme.

The latter requires some explanation. Obviously, there will always be investors who disagree. The very fact that a consensus may be forming will lead some investors to take an opposing view. Synchronization therefore does not imply that all investors have the same view. It means that enough money is betting on one side of a proposition to crowd out "non-believers" during bull markets and "crowd in" such investors in bear markets. The marginal trade takes place at a price that fully reflects the theme.

Synchronization – the emergence of value

If the above is true, we can make the following statement: Under the condition of uncertainty, all synchronizations of expectations represent a mispricing. This is the theoretical basis of value investing.

To illustrate this, assume that there is one asset (say, a biotech company with a new drug in pre-clinical development) with two investors. Investor A, after studying the information that his model considers relevant, does not believe that this new product will be successful. Without it, he arrives at a valuation of 50. Investor B, after equally diligent study of all information she considers relevant, gives the new drug higher success chances, with a resulting valuation of 100. Both investors are equally rational – they just happen to disagree. The market's expectation structure is polarized and the price will be between 50 and 100, say 75. Now assume the two investors meet at a pharmaceutical congress and the bullish investor B convinces the other one of her view. The market structure is now synchronized and the price will be around 100. Both investors of course are still rational[2], but the price is inefficient. Why? Because it now reflects only one side of an uncertain proposition, while "fundamentally" the odds have not changed and the product might still fail.

Modes of infection – the emergence of momentum

How does a market reach a synchronized, i.e. inefficient expectation structure? As suggested above, communication plays a key role here. So, I propose a second hypothesis: Shifts from a polarized to a synchronized expectation structure occur due to self-reinforcing communication processes. This helps to partly explain momentum persistence.

Momentum persistence – or just momentum, for short – simply means that recent winners tend to continue to perform well for some time into the future. Two general forms of momentum are logically possible: Momentum without a shift in valuation levels and momentum with a shift in valuation levels.

The former is a "data driven" form of momentum, where surprise momentum drives price momentum, but no change in the underlying expectation structure takes place. Surprise momentum may happen for a number of reasons, under-appreciated structural change and feedback from the markets to the economy, i.e. reflexivity, being the most common ones, apart from

randomness.
In the latter case, a shift in valuation levels indicates that price change is not just a reaction to "external" data flow, but that an "internal" shift in the market's expectation structure has occurred.
The following is a non-exhaustive list of some possible sources of infection.

- Logical seduction: A popular theme always is a great simplifier. As such, it is often logically stringent and appealing.
- Mounting evidence: As a theme grows in popularity, it attracts an increasing amount of commentary by analysts and journalists. More and more "information" is publicly produced, arguments and forecasting models become more refined and detailed.
- Reflexivity: Market developments tend to feed back on the very fundamentals that they are supposed to reflect. This has been explored in detail by Soros [2003]. Together with the point above, this means that a trend may produce its own fundamentals. In the face of seemingly irrefutable evidence, rejection of a market theme becomes increasingly hard to justify.
- Opportunistic participation: Obviously, many investors use strategies that do not (or not exclusively) rely on fundamental information. Rather, they try to second-guess other investors, reacting to market-generated information. Such strategies come in the form of chart reading, quant momentum models, and so on. The actions of these investors will reinforce a trend.
- Social influence: This is the only "irrational" mode of infection mentioned here. Social influence certainly appears to be quite important in human decision-making[3].

Importantly, as noted before, complexity implies that there is room for such feedback to unfold. In general terms, what I call the attraction potential of a theme is directly proportional to the perceived complexity of the underlying situation, the related time to the potential realization of an outcome, and the significance of potential outcomes for investors.

Reversion without a mean

The cyclical nature of the market is well known. We talk of bull and bear market cycles, of valuation mean reversion, and so on. Typically, commentators attribute this to the existence of a "rational" fair value and "irrational" deviations.
With the ideas developed above, we have no need for an objective, rational fair value. Indeed, there cannot be such a thing if multiple future outcomes are possible – fair value is always a subjective construct dependent on the observer's views. We can explain cyclical swings with the momentum produced by synchronization processes and the reversals produced by the mispricings that result from this. Please bear in mind that such mispricings are simply defined as synchronized perceptions.

Shifting the odds – mispricing and counter forces

More can be said with respect to reversals. Mispricings do not only, by themselves, shift the odds of surprises against the prevailing trend, but they create counter forces that redefine the fundamental thematic background (feedback between markets and the economy shifts from positive to negative). These counter forces emerge in two main areas: in the economy (e.g. supply and demand responses, organizational responses at the company level), and in the response of policymakers. Such counter forces re-enter the market in the form of new themes that compete with the established consensus views. Examples abound – the most recent one being the "whatever it takes" response to the financial crisis adopted at the end of 2008.

The evolution of strategies

So far, we have only talked about "fundamental" expectations. Obviously, investors use many different strategies, from long-term value approaches to high-frequency trading programs. There is no objectively correct way to approach the market. Just as there are a variety of possible fundamental beliefs, there are a variety of possible strategies.
Importantly, what qualifies as information and how this information is processed therefore depends on each respective algorithm. This was discussed above using the example of an earnings announcement. So when we think about investors' expectations, we need to bear in mind that these expectations depend on investors' strategies. The strategies in turn are not fixed, but evolve over time. Which strategies investors select depends on many factors, some of which are briefly mentioned below.

- Education and fashionable academic paradigms: What we learn during our academic education and on-the-job training impacts how we approach the markets. For example, the huge popularity of the EMH in the academic world was a major factor driving the popularity of passive strategies during the 1980s.
- Past success: A strategy that has been successful in the past is likely to gain in popularity. For example, quant models require successful backtesting before a strategy is adopted.
- Technology: Technological progress enables the development of new strategies, e.g. computer-based algorithmic trading programs, derivative strategies, or structured products.
- Strategy crowding: If a strategy becomes very popular, it will impact prices and may create its own inefficiencies. These inefficiencies in turn give rise to new strategies that feed off the old strategies. Think of hedge funds exploiting the inefficiencies created by the passive and quasi-passive institutional dogma. Also, the problem of crowded trades in the quant world falls into this category, forcing an adaptation of quantitative strategies.

Among all possible strategies, what I call the fundamental value code (i.e. value strategies based on the present value of expected future cash flows) has a special importance. As this is the same code as the one used by companies for their investment decisions,

there is a kind of arbitrage relationship leading to negative feedback. High prices will tend to lead to increasing issuance of equity and increasing investment levels, and vice versa. So while it is theoretically conceivable that the fundamental value code disappears from the market and computer-trading dominates price formation, the market would still be coupled to the economy via this feedback loop.

Putting it all together – the general model

Figure 1 illustrates what has been discussed so far. It describes the market as a self-organizing system. It can be considered a general model of the market, located at the highest possible abstraction level. It would remain valid irrespective of specific investor behavior, which from a design point of view is important if one accepts that investor behavior may change (also due to the scientific description itself).

The big circle indicates that the market is a self-organizing system. What constitutes information and how the market reacts to this information is not determined externally, but internally by system processes. There are two key internal processes, depicted by the two smaller circles: The first one is the coordination of investors' expectations. The second one is the evolution of investors' strategies, which in turn impacts what happens in the first process.

Of course, the market is not unrelated to the economy. There is a coevolutionary, two-way relationship between the market and the economy. The economy provides stimulus to the market's communication process. The market selects information from the economy and processes this information according to its internal processes. In turn, market developments feed back on the evolution of the economy. This can be both positive and negative feedback. In figure 1, I have used Soros' term "reflexivity" for this line of feedback.

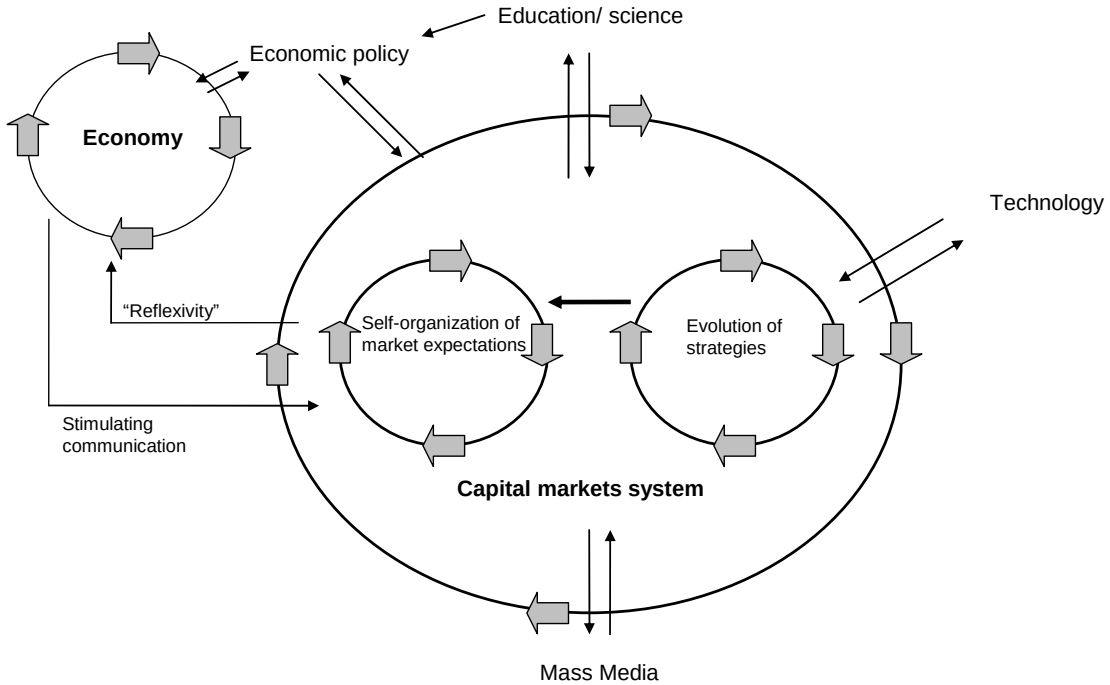
Economic policy (including regulation) has multiple relations. It is impacted by the kind of economic dogma that happens to be popular with policymakers. It impacts the economy, and therefore stimulates the market's communication process. It is also relevant for the evolution of strategies, as regulation may prohibit certain strategies and promote others. And finally, regulation itself is influenced by what happens in the markets.

There is a two-way relationship between the market and academic research. Academic research has an impact on the strategies that investors use. The growing popularity of such strategies in turn may lead to a change in price behavior that requires academic research to adapt to new realities.

There is also a two-way relationship between technology and the market. Technological change leads to the development of new strategies. The money provided by investors in turn stimulates technological development.

The final – and certainly important – element in the network of relations are the mass media. Mass media select themes from the market and in turn reinforce the market's communication of a theme.

Figure 1: The general model of the financial markets as a self-organizing system



From the general to the specific - modeling the cycle of investor expectations

The above model is highly abstract. As such, it does not provide direct help to investors. As stated, it needs to be constructed this way to remain valid irrespective of changing market behavior. The main strength of the model is that it helps us ask questions. For example, we might ask:

- How does the market feed back on the economy (explored in detail by Soros for positive feedback loops)?

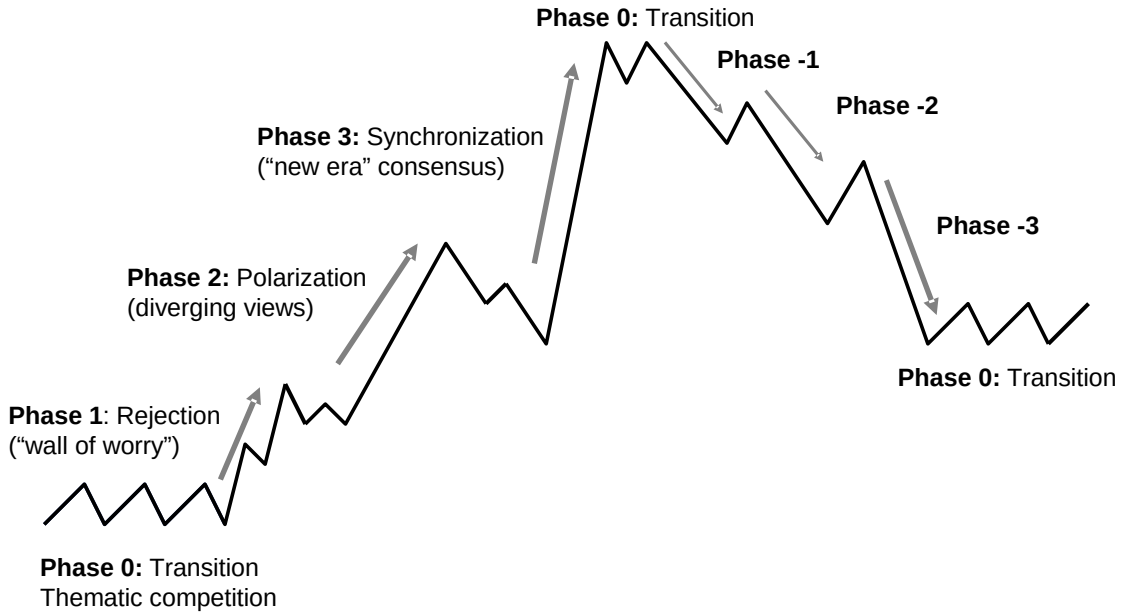
- What impact does the increasing role of computer-based and ETF-related trading have on markets (volatilities, correlations, reaction to news, systemic risks)?
- How to define and measure risk, if risk is not a given property of an asset, but a variable dependent on the state of expectations and the mix of strategies?
- How to design quantitative strategies to take into account the risk of strategy crowding?
- Is adaptive strategic asset allocation superior to standard static allocations as risk/return characteristics of asset classes change due to the market's internal evolution?
- How would economic policy and regulation have to be designed if the market is not efficient in the traditional sense, but a self-organizing system prone to inefficient states?

Here, I would like to ask how we can analyze the state of the market's expectation structure. As discussed above, investors' perceptions are influenced by communication and the related themes. If a new theme emerges, perceptions follow a sequence of

- emerging focus on the theme,
- initial rejection of the theme,
- followed by polarization.

Under certain circumstances (leading to infection of perceptions, as discussed in the respective chapter above), views get synchronized, leading to a momentum move in the market for the related assets. This leads to mispricings and increases the probability of the emergence of counter forces that lay the foundation for a trend reversal. This process is depicted in figure 2. Note that many practitioners use similar models[4].

Figure 2: The market perception cycle



Analysis of the cycle

Importantly, this model would be pointless if there were no way to analyze where we stand in real time. Figure 3 summarizes some analytical rules that I have found helpful in navigating the different phases of the cycle.

Figure 3: Analytical rules for phase assessment

Phase*	Technical structure	Communication/ Sentiment	Capital flows/ Positioning	Valuations
Phase1	Positive divergences, followed by breakouts, increasing momentum and breadth	New bullish theme has emerged, but doubts dominate (wall of worry, show-me attitude)	Institutional flows show rising risk appetite, while positions are still defensive	Move from extrapolation of old bear market theme towards "normalization"
Phase 2	Homogeneous primary uptrend, no major divergences, no trend ending characteristics	No single theme dominates the media, many specific themes Sentiment oscillates between hope and fear	Positive flows, no extremes	Valuations follow earnings trends without developing extreme extrapolations
Phase 3	Accelerations in sub-segments, market becoming more heterogeneous	Increasing dominance of a theme in the media (may well be discussed controversially) extreme sentiment	Strong flows into the dominant theme, extreme position risks Increasing supply	Valuations increasingly show extrapolation bias in hot sub-segments (new era valuations)
Transition/ trend reversal	Loss of trend consistency, trend ending characteristics, (accelerations, sharp reactions against the trend, etc.), divergences (intra- and inter-market)	Dominance of old theme, but new counter theme emerges as a challenger (policy response, supply/demand response, etc.)	Institutional flows show increasing risk aversion against the background of aggressive positions	Extreme valuation differences between hot themes (very expensive) and other segments (cheap to normal valuations)

* Negative phases analogous

Implications for stock selection

Apart from the obvious relevance for asset allocation and market timing, application for stock selection purposes is relatively straightforward in bull phases 1 and 3 and the bear phases.

Phase 1 is a trend change regime where the value generated during the previous bear market is realized. In terms of factors, "normalized value" (e.g. price/trend earnings) will outperform and medium-term (say, 12-month) price momentum will underperform.

Phase 3 is the mirror image of phase 1. This is the phase where investors' perceptions are ruled by "new era" thinking, so value (especially based on normalized metrics) will tend to underperform. The hot segments enter the synchronization phase, so momentum in all its forms (including analyst recommendation and revision momentum) will outperform.

In the bear phases, obviously, defensive stocks will outperform.

In the above phases, factor behavior tends to be clearly defined and alphas tend to be significant. The exception is phase 2. This is the most "efficient" phase of a market cycle. Factor alphas tend to be less stable and smaller. In general, "good/improving" fundamentals at reasonable prices tend to outperform, so standard quantitative multi-factor models tend to work.

Figure 4 gives an overview of factor behavior through the cycle[5].

Figure 4: What to buy in each market phase

Phase 1	Phase 2	Phase 3	Bear Market
Cheap stocks (based on "normalized" metrics)	Good/improving fundamentals (sales, earnings, ROE, etc.)	Recent winners	Defensive stocks (low volaility/beta)
Risky stocks (high volatility/beta)	Cheap stocks (based on traditional metrics, e.g. PE, PEG, etc.)	Positive/improving consensus	Low financial and operating leverage
Losers of previous bear market	Mean reversion: counter-cyclical rebalancing	Expensive stocks (based on "normalized" metrics)	Avoid downside leaders

Empirical evidence

In the following, I discuss some evidence. This is intended as a plausibility check, not as rigorous empirical testing. Some of the problems in empirical testing are also touched upon.

Trends and cycles

In academic circles, trends and cycles are contentious issues, even though among practitioners there seems to be a strong consensus that they exist. Maybe the problem is one of perspective. Academics approach the issue from a statistical point of view. Investors, in contrast, experience first hand the effects of trends and related themes on our minds, so they tend to sympathize with the view that "something" is going on.

A graphical case for the existence of cycles (and hence trends) is made in figures 5 and 6 (data from Robert Shiller's webpage and from Datastream). Figure 5 shows the de-trended inflation-adjusted total return series for the S&P 500 Index (deviation from the time-regression trend[6]). What you see here is what many investors refer to as secular bull and bear markets or the long wave cycle. It is irregular, but still clearly displaying cyclical characteristics. Remarkable (but not necessary for the case) is the relatively stable amplitude of around +100%/-50%.

Figure 6 shows the deviation of this de-trended series from its 5-year centered moving average. This results in a cycle that practitioners generally refer to as bull and bear markets. I call it the primary cycle. While the amplitude is variable, the frequency is remarkably stable at around 4 years from low to low (again, interesting, but not necessary for the case).

Figure 5: the secular cycle: de-trended S&P 500 real total return index with 5-year centered moving average

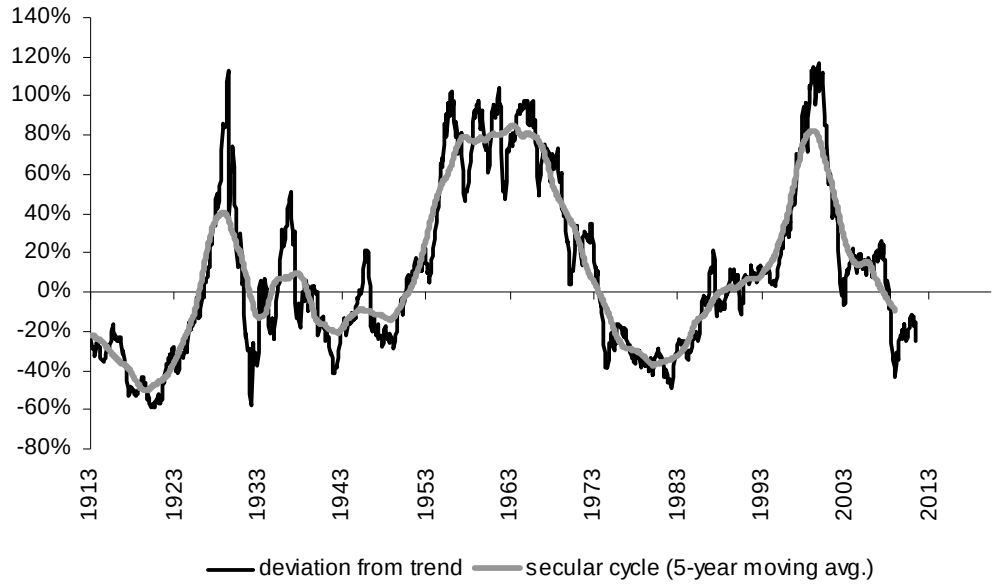
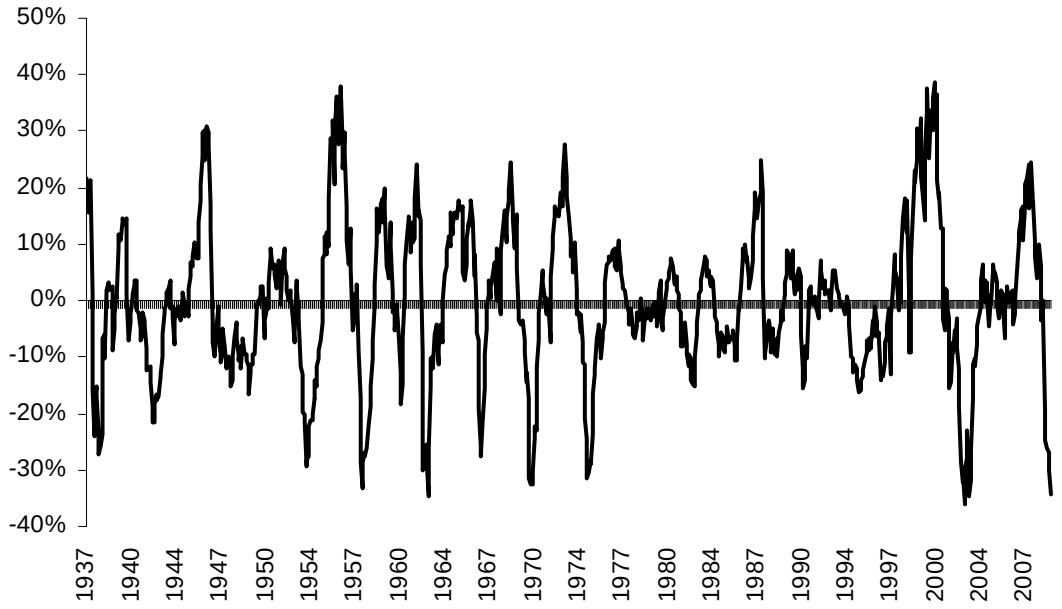


Figure 6: the primary cycle: deviation of de-trended S&P 500 real total return series from its 5-year centered moving average



Synchronization, momentum and value

This paper claims that processes of perception synchronization lead to momentum and end in mispricing. How could one empirically test this? First of all, the fact that valuations tend to mean revert (i.e. expensive stocks tend to underperform and vice versa) is well

known. It would be helpful to analyze valuations and returns in a bit more detail, trying to specifically answer the question whether evidence of shifts in the market's expectation structure (between polarization and synchronization) can be found. Unfortunately, I do not know of a way to test this in a standard statistical way. Testing would have to take into account the thematic drivers of valuations, which calls for a case study approach (which I understand is not generally regarded as a valid approach in academic finance).

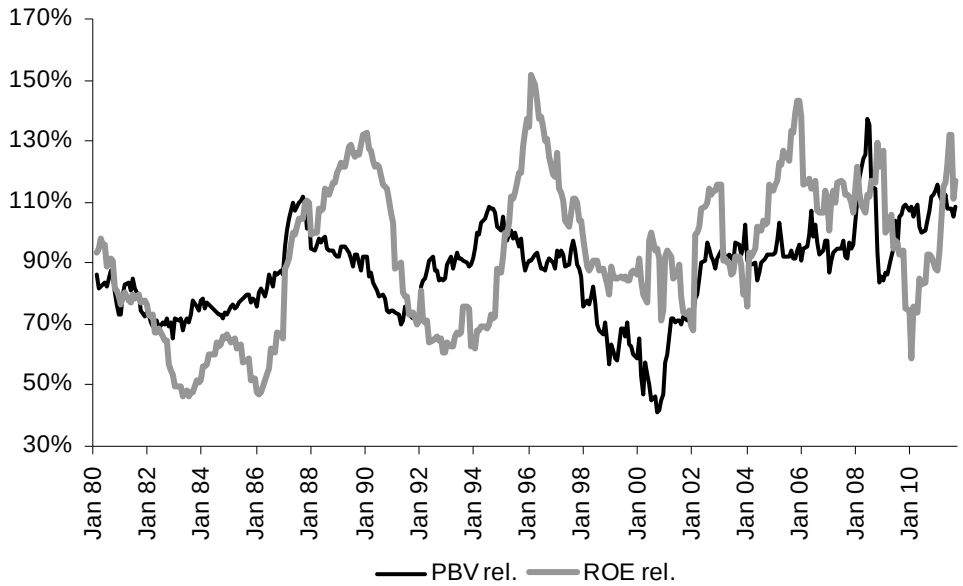
Another, related issue that would require empirical testing is the impact of communication on momentum and valuations. This could also be explored in a case study approach. In addition, even though this is not trivial, advances in natural language processing may have made it possible to examine the question in a statistical way.

Finally, and also related, the link between momentum, valuations and subsequent returns could be examined. While conceptually simple, note that this research would need to be carried out on a bottom up, stock-by-stock basis. Standard simplifying techniques like aggregating stocks into percentile groups or portfolios will not yield sensible results. The reasons for this are the facts that different phases for individual stocks overlap too much in most periods and that the time it takes for these processes to play out varies considerably between individual cases. The only exception are periods when phase 3 extremes are highly correlated by a common theme (like, for example, during the final stages of the technology bubble).

Below I would like to provide an anecdotal example that I consider to be quite typical of what is happening in the markets. In order to facilitate understanding the example, let us first perform a little thought experiment. Assume that there is an AAA-rated bond whose coupon payments are not fixed, but fluctuate in a clearly pre-defined cycle (say, alternating between USD 8 and USD 12). Further, assume that the interest rate for comparable fixed-coupon bonds is 10%. Obviously, the price of the bond would not fluctuate with the actual coupon payments, i.e. it would not swing between USD 80 and USD 120. Rather, the market would discount the fluctuating, but known future cash flows at the given interest rate and the price of the bond would stay fixed at USD 100, similar to a fixed-coupon bond. In equity terms, the bond's "price/earnings ratio" would fluctuate without making the bond "cheap" or "expensive", while the bond's "price/book value" would stay constant. In other words, the market would "normalize" the cyclical swings in coupon payments.

Turning to equities, figure 7 shows the valuation and profitability of the US basic materials sector relative to the total market ex financials (using Datastream data and sector classification). Until 1998, a "normal" pattern could be observed. While both valuations and profits fluctuated, the former tended to "normalize" swings in the latter to some degree. Investors "knew" that profits in the basic materials sector were cyclical, and valued the stocks accordingly.

Figure 7: relative valuation (price/book value) and relative return on equity of the US basic materials sector



Starting in 1998, the situation changed. Relative valuations reached a major low in 2000, driven by the phase 3 bubble in the "New Economy" and the mirror-image relative bear market in the "Old Economy". As a result, valuations in 2000 reflected the extrapolation of hugely diverging trends in relative growth and profitability between old and new economy. In terms of the model presented above, the phase 3 synchronization ended in inefficient valuations, creating significant relative value in the neglected sectors.

Phase 1 of the new relative bull market in the basic materials sector was driven by the bear market in new economy stocks 2001-2003. In valuation terms, this phase was characterized by the normalization of the previous extremes.

Between 2003 and 2007, the new bull market theme "BRIC" (short for Brazil, Russia, India, China and referring to the structurally increased demand growth from the emerging markets) became increasingly well known. Throughout 2007, media coverage and participation by the general public was growing strongly, reaching mania proportions around the turn of 2007/2008. Still, during this entire period, valuations remained rather stable and "normal", implying that investors treated the high profits of this time as cyclical, not structural. This is what characterizes a phase 2.

This changed in the first half of 2008. While the general market had already entered a bear market, driven by the financial sector, the old BRIC theme and related sectors (commodities and commodity producers), entered a final phase 3 as the only game in town on the "global decoupling" theme. Note how valuations spiked up to new highs, roughly in line with previous cyclical peak profits. This meant that investors were pricing the expectation that the sector had structurally shifted its profitability level higher ("stronger for longer", "super cycle"), with the old peaks being seen as the new normal level (equivalent to our bond in the thought experiment above trading at USD 120, extrapolating the coupon payment of USD 12 into the future). This kind of extrapolation is what defines a phase 3 synchronization. The episode was concluded with a crash in the third quarter of 2008.

Conclusion

The main research question raised in this paper is the following: Is the market a nontrivial machine? To my knowledge, this question has not been asked and answered before. If one thinks that the answer is yes, then systems theory offers an explanatory framework that, while not popular in finance theory, is an established approach to deal with circular or self-referential causality.

This paper does not pretend to explain everything that is going on in the markets. However, by taking a fresh perspective, I hope the reader will find that it contributes to our understanding of some of the empirical phenomena, including what I call the key market facts: uncertainty, diversity of opinions, communication, trends and trend reversals. In a nutshell, uncertainty leads to differences in opinion, which in turn promotes communication. Communication synchronizes perceptions, which leads to trends and ends in mispricings and trend reversals.

On an abstract level, the financial markets are modeled as a self-organizing system, with its internal structure impacting its response to external input. The internal structure is defined by the state of two self-referential and linked processes: the coordination of expectations and the evolution of investment strategies. The former can be modeled as a process consisting of four phases: emergence of a new theme and thematic competition (phase 0), focus on new theme amid widespread rejection (phase 1), polarization of opinions (phase 2), and synchronization of opinions (phase 3). Synchronization leads to momentum and ends in mispricings that increase the probability of a trend reversal.

An analytical framework was introduced that helps navigate these phases in real time, integrating technical analysis, thematic analysis, analysis of sentiment, flows and investor positioning, and valuation analysis. This model can not only be used for asset allocation and market timing purposes, but also for security selection, as factor behavior is related to the phases of the perception cycle.

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[1] "Die Hypothese hinter der Analyse", www.unifinanz.li. See also Cortés and Rizello [2007].
[2] Investor B was assumed to have a reasonable opinion. This remains reasonable regardless of whether A agrees or disagrees.
[3] See, for example, Lorenz et al [2011]
[4] For example, Alfons Cortés and David Fuller
[5] Stifel Nicolaus' EquityCompass Strategies division has a similar model.
[6] To calculate the deviation from the trend, only data available at that time was used to estimate the trend. Thus, the trend value for Dec 1910 is calculated using monthly data for the period Jan 1871-Dec 1910. After that, the starting point of the regression is kept constant, while the end point is shifted out in one-month steps, ending with a regression from Jan 1871-Sep 2011 for the most recent data point.

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